AN OPEN AND SCALABLE LEARNING INFRASTRUCTURE FOR FOOD SAFETY

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ABSTRACT

In the last several years, a variety of approaches and tools have been developed for giving access to open educational resources (OER) related to food safety, security, and food standards, as well to various targeted audiences (e.g., farmers, agronomists). The aim of this paper is to present a technology infrastructure currently in demonstration mode at Michigan State University that will collect various agricultural education content (training descriptions, open educational content, competencies, and standards) and provide them through various interfaces, based on the needs of the targeted audience. The overall architecture of the infrastructure for the food safety sector and the needed components are presented, as well as the main usage scenarios that explain how the infrastructure can enhance existing platforms and services in the area of food safety and food security.

KEY WORDS

Food safety, competencies, metadata, Massive Open Online Courses (MOOCs), open educational resources (OER), open content, OpenCourseWare (OCW), online learning, agriculture, discoverability, search, information communications technology, Food Safety Knowledge Network (FSKN)

I. INTRODUCTION

Advances in information technology have increased the amount of information available in food safety. Michigan State University is demonstrating that information providers must go beyond providing information by employing a technology infrastructure that builds from multiple sources. Most service providers and data and knowledge organizations have done little to remove restrictions imposed on users regarding the type, scope/breadth, and depth of knowledge that is available to them. A variety of approaches, such as global search engines, have been developed to provide access to content and to filter content by content domain for all domains and target groups. Examples include the GLOBE initiative, which provides a generic, Google-style search engine for educational content [1], courseware-oriented networks like OpenCourseWare (OCW) [2], and OER-focused aggregators such as OER Commons [3], but also domain−specific networks such as Organic.Edunet for organic agriculture education [4].

However, a significant variety of content is still missing, as it is inaccessible or unknown to the potential target groups. The main cause appears to be the lack of clear policies and little or no awareness about how to openly share learning opportunities and content, as well as a lack of thematic networks that would

allow people to search and discover the right content for their information needs. Although a large number of such learning portals have been deployed, there are not many that are specifically designed for agricultural education [5, 6]. However, technology infrastructure is now being put in place to facilitate the development of such portals, based on the principle of metadata aggregation from various distributed sources [7].

Our overall aim is to put in place a technology infrastructure that will collect and provide a rich content base through numerous interfaces and modalities for various agricultural education contexts and scenarios. Efforts toward the coordination of this work have taken place in the context of the Agricultural Learning Repository Task Force (AgLR-TF) [8] and have led to the development of data pools such as the Green Learning Network of agINFRA [9].

Overcoming the technology challenges becomes more critical when the content is of extreme priority and importance on a global scale. The topic of food safety belongs in this category. Food safety focuses on the way food should be handled, prepared, and stored to prevent foodborne illness. A number of recent initiatives have been launched focusing on this topic, such as the FoodSafety.gov gateway in the United States, the food safety program of the World Health Organization (WHO) [10], and the Food to Fork action line of the European Union [11]. In a similar way, large industrial players have teamed up to align their efforts on global food safety standards and benchmarking [12].

There is also a wealth of institutions and projects that offer access to good educational resources related to food safety and food standards, ranging from training opportunities and courses to open educational resources, and from targeted/needed skills and competencies to certification opportunities and courses. Still, these resources cannot be easily discovered by those who need them, especially on a global scale. As in other areas of agricultural education, there is a need to pool together the variety of resources on food safety and standards in a baseline infrastructure that will enhance their discoverability.

This paper introduces an approach that can help address this challenge that is currently being demonstrated through the Michigan State University Food Safety Knowledge Network (FSKN): taking advantage of current advances in e-learning technologies and standards in order to set up a learning infrastructure for food safety that will be open and scalable. To this end, the paper describes the overall architecture and components of such an infrastructure, and then describes a number of usage scenarios that demonstrate how it may enhance existing platforms and services.

II. BACKGROUND

A. E-Learning and Agricultural Education

Agricultural education is defined as the teaching of agriculture, natural resources, and land management through hands-on experience and guidance [13]. It focuses on educational practices and methods that will help prepare students for entry-level as well as advanced agricultural jobs. Agricultural education has a strong connection to the concept of agricultural extension [14] that was established in more highly developed countries to help rural populations evolve beyond the level of maintaining subsistence agriculture with limited industry.

The extension officer, working for a variety of rural services and institutions on an agricultural extension service, serves as the educator and mentor of the farmers and rural businesses. Still, under the umbrella of agricultural education, one may find programs taught also at the elementary, middle school, secondary, postsecondary, and adult levels [15]. Agriculture is introduced in schools to teach subjects such as how plants and animals grow and how soil is farmed and conserved. Professional (or vocational) agriculture is introduced to prepare people to work in jobs in areas such as production, marketing, and conservation of agricultural products. Academic (college or university) agriculture focuses on training people to teach, conduct research, or provide information to advance the field of agricultural sciences. Finally, general education agriculture informs the public about various topics related to agricultural sciences and products, such as food safety.

The introduction of e-learning technology (or technology-enhanced learning) to support agricultural

education is still in the early stages of adoption compared to other application domains. As Leary and Berge [16] have identified, early pioneers, such as American and Australian agribusinesses and colleges of agriculture, utilized e-learning methods as a major part of their education and strategic management programs. Still a number of challenges exist concerning the faculty and trainers, students and farmers, technology, finances, and other complications. Nevertheless, agricultural education institutions are eager to overcome such challenges and have started developing e-learning materials to supplement existing printed course materials or substituting parts of their programs with online components [17].

Distance agricultural education is most commonly designed to support professionals who are interested for their personal and career development or who are asked to acquire specific skills. In those cases, trainees work in an interactive environment with other trainees, following a flexible and adaptable online course [18]. Distance learning also supports rural people (e.g., farmers) in remote areas who are not well informed on the up-to-date techniques and practices in agriculture by providing training lessons in various agricultural topics. Learners have the chance to be trained at their own place and time [19]. In India, several universities provide basic educational opportunities for students at a distance, and additionally they focus on the production of a model for the training of mid-level skilled farmers and rural youth [20]. The survey "Developing Distance Learning Framework for Promoting Agriculture Education among Farmers in Uttarakhand" revealed that the majority of trained farmers (around 86%) accepted the importance of the distance learning for the enhancement of their skills and knowledge about already existing infrastructure in agriculture [20].

In Africa, several distance education in agriculture training programs have been developed in the last several years for youth in order to enhance the sustainable improvement of food security and to protect natural resources and the environment. For example, the Directorate of Distance Education (DDE) at the University of Zambia offers distance training to the farmers of southern Africa, with the Commonwealth of Learning [21]. Also, several training centers provide distance-learning opportunities to various targeted audiences in a wide range of agricultural topics, from basic cultivation techniques to building business plans. For example, the Academy for Distance Learning, from the United Kingdom [22], delivers distance training at an advanced level, such as the "Advanced Diploma in Plant Science" for completing approximately 800 learning hours, as well as online training covering basic knowledge, such as "Animal Breeding," which has a duration of 100 learning hours.

In the United States, land-grant universities have agriculture extension services and also participate in the online eXtention initiative. As an example, MSUglobal at Michigan State University leads initiatives providing online training in agriculture topics, food safety and security, and environmental protection. Such projects include My Horse University [23], AgShare [24] and the Food Safety Knowledge Network [25] for the development of open-access learning material for the food industry. In addition to distance and online learning, there is also a growing number of learning resources and OER, including Massive Open Online Courses (MOOCs).

The Global Food Protection Institute (GFPI) [27] is a nonprofit organization that focuses on the improvement of public health and the economic factors associated with foodborne illnesses. Studying the existing training courses for the food safety sector, the GFPI research team identified the following challenges: (a) lack of standardization, (b) non-competency-driven content, and (c) lack of consistency and peer review focusing on the variety of private and public food-safety standards that should be used in the development of food-safety courses. Their conclusions illustrate the need for better alignment and improved discoverability of food safety training and resources.

III. AN OPEN AND SCALABLE LEARNING INFRASTRUCTURE

At Michigan State University, we are demonstrating an open and scalable learning infrastructure for food safety. We are designing, developing, and deploying a technology platform that will be periodically ingesting data about food safety educational resources, both from MSU FSKN repositories as well as from external sources. This technology platform is based on the principle of metadata aggregation rather than local storage of the digital resources themselves: that is, it will provide the necessary mechanisms (in

terms of automated software tools) and user interfaces (in terms of functionalities and features) that will support the identification, indexing, curation, enhancement, and publication of metadata descriptions for the various information types of relevance to food safety educational stakeholders. This platform includes the following:

- Mechanisms in which educational offerings (such as online, blended, or physical courses on food safety topics) will be published and advertised.
- Mechanisms in which OER on food safety topics (such as lecture recordings, slides, notes, lesson plans, and good-practice guides) will be shared and discovered.
- Tools and interfaces to catalogue, view, and navigate food safety related skills and competencies.
- Tools to map food standards in interoperable and machine-readable representations, facilitating their alignment.
- Multiple access points and interfaces to the information using various devices.

The overall architecture of the infrastructure is presented in Figure 1. The paragraphs that follow discuss in more detail how each layer functions.

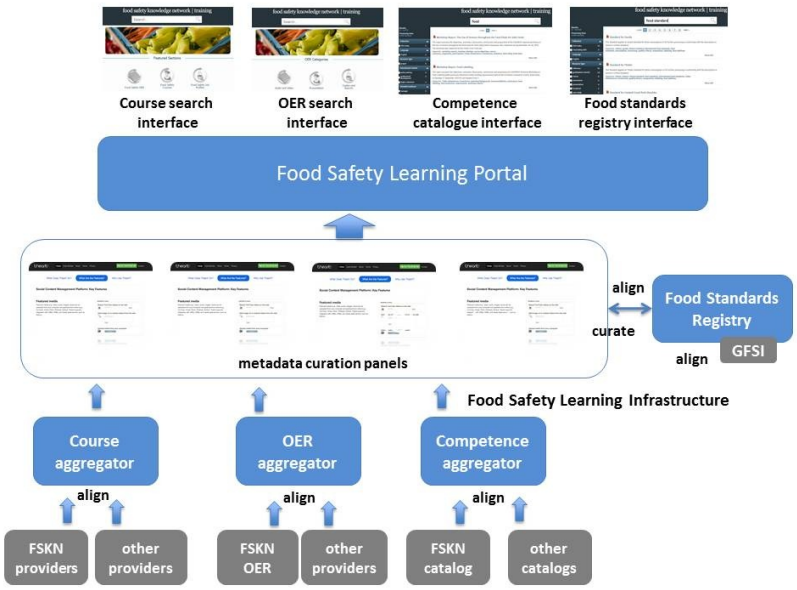

Figure 1: Overall architecture of learning infrastructure

A. Educational Offerings Aggregation Back-End

The core layer of the demonstration infrastructure is the back-end layer that is responsible for aggregating food safety educational resources (referred to as the Educational Offerings Aggregation Back-End). It includes the technology components that handle the periodic collection of descriptions of food safety resources, and more specifically the aggregation modules that deal with each different type of data. The backend must collect metadata descriptions for several types of content:

- Food safety courses, including both FSKN and external collections and providers. Examples of FSKN providers include MSU colleges and educational programs such as the MSU online courses offered through the MSU Learning Management Platform, ANGEL [28]; external providers could be universities participating through the OpenCourseWare Consortium [2] or those offering a MOOC through a platform like Coursera [29] or Udacity [30].
- Digital educational resources in other forms, such as lecture slides, training guides, project descriptions, case studies, multimedia material (videos, photos, audio), etc. This type of material can come from both FSKN and external providers. Examples of FSKN resources include

materials such as presentation slides in various formats and languages, transcripts of presentations, and audio and video versions of lectures, all of which were developed on various aspects of food safety topics, such as cleaning and disinfection [31]. Examples of other providers are educational portals and aggregators that have educational material on agricultural and food topics, such as OER Commons Green [32] and Organic.Edunet [4].

- Job profiles in the food industry, specifically in relation to food security and safety. These job profiles need to be elaborated to the level of required skills and competencies. This refers to, for example, competencies required by the individuals who are responsible for managing food safety in a company. The competencies need to be expressed following a standardized process (essentially a job task analysis) that will describe for each job profile the specific knowledge and skills required for the individuals in a company who manage food safety on a daily basis. FSKN used as the initial basis the company characteristics framework of the Global Food Safety Initiative (GFSI) [12], but additional competency representation schemes may be aggregated.

In order for these incoming sources of heterogeneous metadata to be ingested and aligned with each other, this infrastructure layer will also include mechanisms that external providers may use to declare the metadata properties that they are using and those properties' value spaces (e.g., controlled vocabularies, thesauri, ontologies) as well as to link or map them to the ones internally used in the infrastructure. For example, a subject classification used internally to tag food safety courses in a training provider's system can be mapped to the one used in the learning infrastructure (as well as generic ones widely used such as AGROVOC) in order to create automatic crosswalks from one to the other. The incoming data streams will be curated and validated though a number of administration panels that will be working over the infrastructure's back end. They will allow both domain experts and technology experts to monitor, review, edit, and approve the flow of information and the way it is being exposed to the front-end layer applications.

B. Registry and Alignment Layer for Food Standards and Reference Curriculum

An additional proposed layer is one responsible for the standards registry and alignment. This is a layer that may efficiently facilitate the alignment of various food standards (currently taking place at a conceptual and not machine-reproducible way at the GFSI site), as well as allow food safety training providers to carry out a similar alignment of their training curricula using a reference curriculum that may be developed by GFSI stakeholders. This layer will achieve two aims:

a) It will replicate the existing food schemes benchmarking process that is taking place at GFSI, allowing food standard/scheme owners to describe and submit online their benchmarking application for crosswalking and recognition against the processes and dimensions of the GFSI Guidance Document. This process, which is currently taking place using paper applications, can be fully moved online by using digital representations of the food standards and their components. Graphical mapping tools and applications may then help scheme owners describe their standards and map them to the corresponding GFSI dimensions they connect them with.

b) It will carry out a similar alignment process for food safety curricula, allowing education providers that offer some training opportunity (online, blended, or face-to-face) to link their curricula to a reference curriculum that will be used within the infrastructure and that will also express learning outcomes in terms of food safety skills and competencies. The graphical mapping tools will help providers describe their curriculum and link it to the reference one.

This proposed layer can greatly facilitate the operation of technology services and tools across the learning infrastructure, since it will make it possible to:

- Represent any food safety curriculum (and especially the reference one) in an interoperable format using learning outcomes, skills, and competencies.

- Facilitate the generation of multilingual versions of a food safety curriculum, in order to be used or linked to the systems of providers in any country or geographical region.
- Support the generation of transformable curricula representations that will allow users of front-end applications and services to navigate and browse through curriculum areas using their preferred curriculum format.

C. Front-End Services and Applications

The front-end layer of the demonstration infrastructure includes deployed services that illustrate its potential but also provides open mechanisms through which additional services may be developed. It is designed as a layer that will expose all the information aggregated by the back-end in different ways and using different formats so that a variety of third-party applications (ranging from web portals and sites to mobile applications and widgets) may be connected.

The main way to access all of the information aggregated in the infrastructure is through a web portal. This portal is currently an enhanced version of the existing FSKN website, which allows users to discover food safety resources of various types. The web portal is also expected to support and demonstrate various interaction modalities (visual, device, thematic, geographical, industry sector, etc.) in the way that users search for and discover the information. In the future, the portal could also offer multilingual interfaces and metadata, facilitated by automatic translation engines.

D. Demonstration Projects

To make the FSKN demonstration project as realistic as possible, we have used the existing agricultural learning infrastructure of the Green Learning Network (GLN) [33] that is federating, aggregating, and indexing educational collections on all areas of agriculture and biodiversity. For the FSKN demonstration described below, the following tasks were completed:

- Creation of a sample population of a learning repository with food safety resources: This task concerns the population of a new learning repository with a sample of high-quality metadata descriptions of food safety relevant courses, OERs, job profiles, and competencies. We worked together in order to index resources from FSKN as well as other relevant sources (such as Food & Agriculture Organization of the United Nations, FAO, WHO, and Codex Alimentarius). The populated repository was connected to the GLN metadata aggregation infrastructure, and its resources have been harvested and exposed through appropriate APIs.
- Development of operational search page demonstration: This task concerns the deployment of a number of search and discovery web page prototypes that demonstrated how lightweight but efficient interfaces and mechanisms can be developed on top of such a learning infrastructure. The deployed prototypes illustrate how such a page may be integrated into the existing website of FSKN and in two other existing sites of relevance. These page demonstrators are operating on top of the APIs that tie into the GLN infrastructure.

These features help users discover relevant content not only from the MSU FSKN but also from sources external to the FSKN. Three demonstrations have been developed:

- FSKN training site [34]: a prototype demonstrating how new educational resource search pages may be deployed within the existing site of FSKN [35]
- Codex Alimentarius site [36]: a prototype demonstrating how material related to the Codex Alimentarius food standards can be deployed within the existing site of Codex [37]
- Coursera platform [29]: a prototype demonstrating how existing course pages in an online course platform (such as a MOOC) may be enhanced with OER search features [38]

The true potential of having such an infrastructure in place will be unleashed by the deployment of additional learning applications and platforms that will be built (or connected) using open APIs to access

the various types of information within the infrastructure. Such applications may be mobile/smartphone/tablet apps for various operational systems (such as iOS, Android, and Windows 8) that will serve as search interfaces to the content. These interfaces can be embedded in other websites and portals to allow searching into relevant content within other sites, and new platforms that will provide new shells around the content, providing novel ways in which the information may be discovered and visualized.

IV. USAGE SCENARIOS

To demonstrate the use of the learning infrastructure, we use the hypothetical example of a small meat producer in Paraguay that is exploring how it can start selling its packaged cooked ham to an international food distribution company. Their product is a high-quality one, made from pure pork ham. Still, they would like to find out more about the food safety standards of cooked ham.

Figure 2: Prototype demo of the enhanced search page of the Codex Alimentarius website [37]

The manager of the meat producer visits the Codex Alimentarius site (Figure 2) to find out more about cooked ham standards. She starts searching the content of the portal by entering the term "ham" in the search box of the portal and gets a result on "Standard for Cooked Cured Ham," which she views to get more information about the standard. As Figure 3 shows, the resource is a Codex Standard for Cooked Cured Ham that is addressed to managers. Our user clicks on the resource to download the document and read it.

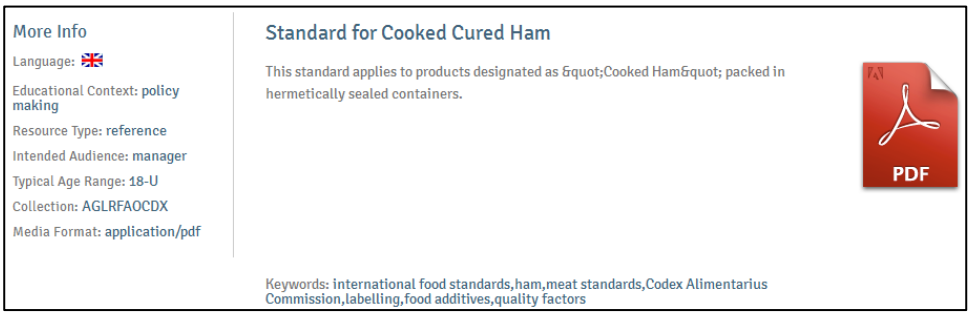

Figure 3: Viewing the metadata description of the cooked cured ham [37]

Reading through this document, the manager finds all the necessary information for ensuring that the company's cooked ham products comply with the Codex standard. In addition, she finds a section that refers to the specific labeling that packaged cooked ham should have to adhere to the standard. Interested in finding out more about this, the user goes to the new FSKN search page (Figure 4).

Figure 4: Prototype demo of FSKN search page offering access to a variety of food safety resources [35]

At the FSKN site, the manager decides to look for a guide explaining food labeling procedures. She scrolls down the page and clicks on the "Educational Resources" icon. A landing page with the educational resources indexed by FSKN opens. She clicks on the "Guides and Reports" category icon and a list of results with relevant guides appears. Since more than 100 resources are listed in the results, she decides to search into these results by using "Food Labeling" in the search box. A shorter list of relevant results is generated, through which she identifies a "Guide on Food Labeling - Complete Texts" (Figures 5 and 6). She clicks on "View More" and reads the description and sees that this is a guide published by the WHO and FAO, presenting food labeling requirements in a compact format. After downloading and reading the document, the manager of this small company can suggest a revision in the way that the labels of their pork ham products are generated so that they comply with the general requirements.

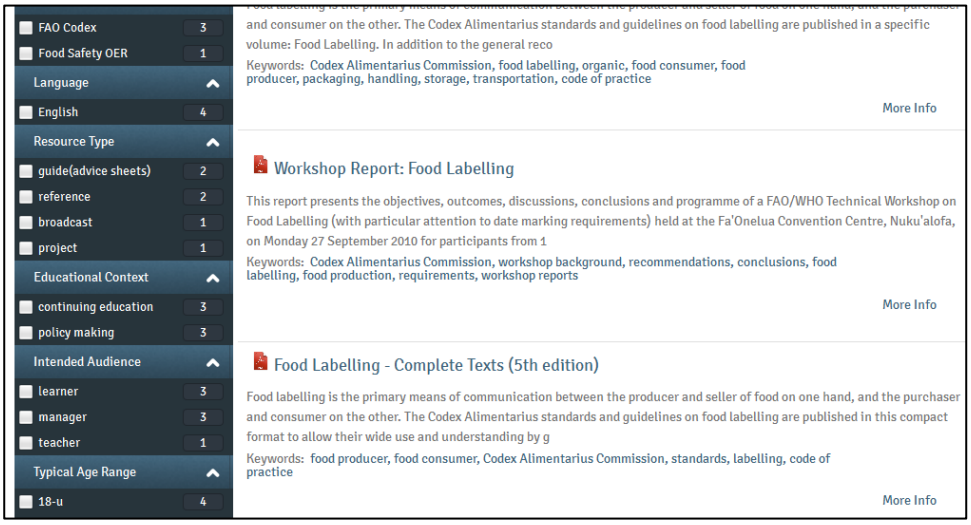

Figure 5: Searching for a resource on food labeling [37]

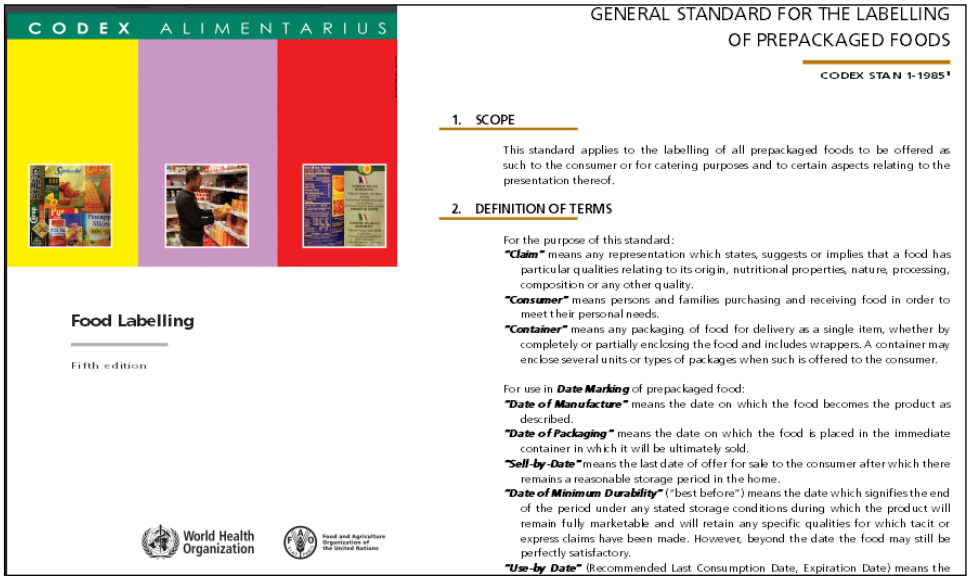

Figure 6: Finding a WHO/FAO comprehensive guide on Food Labeling [37]

Later on, the manager of the small meat producer finds out that the large food distributor they would like to work with is requiring its providers to apply the HACCP standard procedures. She is visiting the FSKN site again and uses the term "HACCP" in the search box. A list of results appear, among which is an online course on HACCP Basics for Processors and Manufacturers. The manager goes to the website of this course where she finds out that for a small cost she can get a better understanding of key HACCP concepts and the steps required to properly implement them in her company. Searching further for OER, she also finds a number of good YouTube videos that explain the principles of HACCP for food safety (e.g., Figure 7).

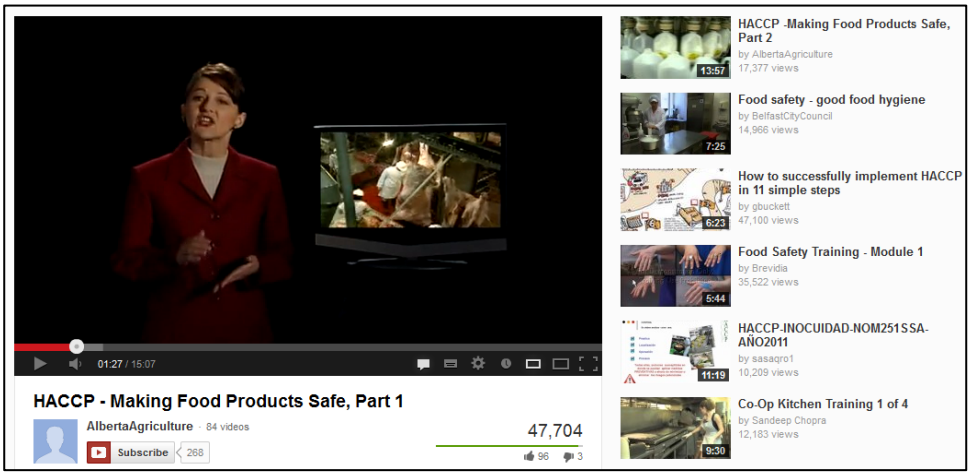

Figure 7: An introduction to HACCP principles for food production discovered through the demonstration FSKN portal [39]

Finally, the manager of the food company decides to also register for an online MOOC on food systems in order to get a better idea of how the global food sector works. She visits the site of the Coursera platform [29] and searches for courses related to "food" using the search box. From the list of relevant courses, she finds an interesting one called Sustainability of Food Systems: A Global Life Cycle Perspective and clicks on the course title. A page with more information about the course opens (Figure 8).

Figure 8: Typical course page in Coursera [38]

In this course information page, she can scroll and find out more information about the thematic categories in which the course belongs as well as browse for more courses. In the FSKN demonstration page developed as a prototype, she can also search for educational resources that are relevant to this particular food safety course, either by clicking on the general "Browse more relevant OER" button, which returns a list of relevant material that can be found in FSKN, or by looking into specific types of resources like audio and videos, presentations, or guides and reports (Figure 9). The manager can now register for the MOOC while she is finding relevant material on food systems that she can use for self-study.

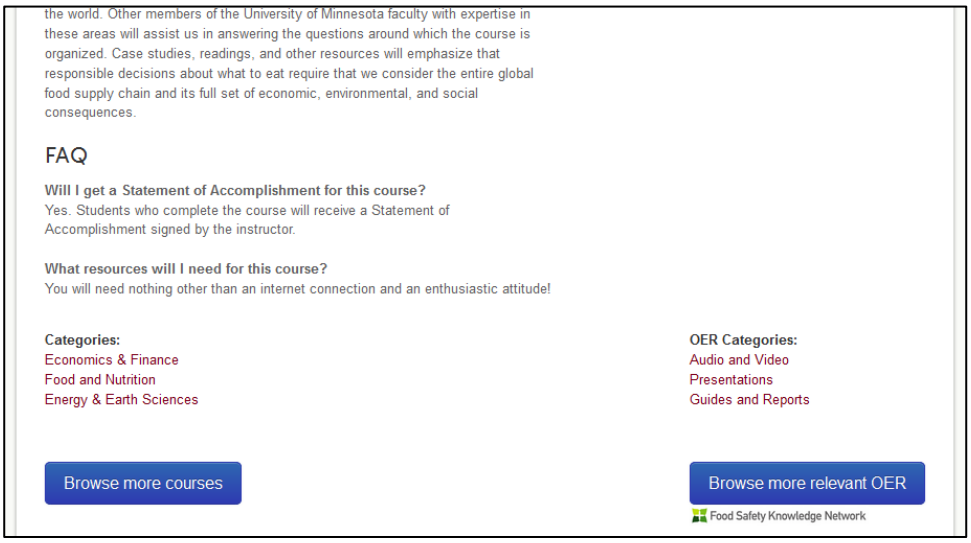

Figure 9: Demonstration of FSKN-enhanced Coursera page with information about a course [38]

V. CONCLUSIONS

In this paper we describe an open and scalable learning infrastructure created as a demonstration project for the Michigan State University FSKN. We present the main objectives and the challenges of such a global food safety network, describe the rationale and the components of such a food safety learning infrastructure, and provide an overview of current technologies and standards that can make such an infrastructure a reality. Emphasis is placed on scenarios that explain how such an infrastructure may prove useful to people searching for learning material appropriate for their needs.

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VIII. ABOUT THE AUTHORS

Nikos Manouselis is a co-founder and the CEO of Agro-Know Technologies, Greece. He has a diploma in Electronics and Computer Engineering, an MSc in Operational Research, and an MSc in Electronics and Computer Engineering, all from the Technical University of Crete, Greece. He also holds a PhD in the application of metadata technologies in the domain of agriculture, from the Informatics Laboratory of the Agricultural University of Athens (AUA), Greece. Nikos has extensive experience in designing and implementing large-scale initiatives related to open data and applications for agricultural education, research, and innovation. His research topics of interest include learning repositories and portals, educational datasets and analytics, as well as social navigation and recommendation.

Charalampos Thanopoulos is an associate researcher at Agro-Know Technologies. He has a diploma in Crop Science, Specialization in Vegetable Crop Production, an MSc in Modern Systems of Crop Science, Plant Protection and Landscape Architecture Specialization in Plant Physiology of Vegetables and a PhD in pre-/post-harvest physiology of vegetables, all from the Laboratory of Vegetable Production of the Agricultural University of Athens, Greece. Charalampos has strong experience in the development of learning objects, implementation of metadata schemas for the description of learning resources, creation of educational and training scenarios, and identification of competencies for professional training in agricultural topics.

Christine Geith, PhD, is Assistant Provost and Executive Director of Michigan State University MSUglobal Knowledge and Learning Innovations. She leads the development of new entrepreneurial approaches in higher education using educational technology, online learning, and open models. Recently, she has worked with faculty to open up critical knowledge to help transform global food systems and agriculture. She was previously at Rochester Institute of Technology as Co-Director of the Educational Technology Center and Director of Distance Learning. Christine has a PhD from the University of Nebraska, Lincoln, and an MBA from Rochester Institute of Technology.

Karen Vignare, PhD, currently serves as Associate Provost of the Center for Innovation in Learning at University of Maryland University College, leading the search and evaluation for next generation learning models. Karen is responsible for implementing collaborative innovations that may include prior learning, course design, analytics, adaptive learning, e-resources, open educational resources, instructional design changes, and competency based models. She was previously a Director at MSUglobal at Michigan State University. MSUglobal is responsible for helping departments at MSU integrate emerging technologies. She has a PhD from Nova Southeastern University and an MBA from the University of Rochester's William Simon School of Business.